POLYTETRAFLUOROETHYLENE TUBING AND
METHOD OF MAKING THE SAME

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This invention relates to polytetrafluoroethylene tubing
and method of making the same and has for an object
the provision of improvements in this art.

One of the particular objects is to provide a tube formed
of polytetrafluoroethylene ("P.T.F.E." or "Teflon" or "H"
as it is variously designated) which has great circumferen-
tial strength. Such a tube is especially useful for forming
terminal sleeves for electrical conductors which are
crimped to secure them on the terminal heads.

It is now a common practice to extrude tubing of this
plastic from a mixture of the flocculated unsintered mate-
rnal and a plasticizer or extender aid, then to eliminate
the plasticizer by vaporization or otherwise and there-
after sinter the tubing. However, this extruded tubing,
even after sintering, lacks the necessary circumferential
strength to withstand crimping without splitting or crack-
ing.

According to the present invention a tube is formed
by winding a plurality of layers of plastic tape or sheet
on a mandrel and thereafter sintering it. It is not satisfac-
tory merely to wind the sheet in any fashion and in
random orientation on the mandrel because of the fact
that unoriented polytetrafluoroethylene has a very high
coefficient of thermal expansion and when heated for
sintering will expand so much that it will move free of
the mandrel and accurate dimensions and suitable wall
density cannot be attained.

The present invention overcomes this difficulty by form-
ing the tube windings from calendered sheet or tape
with the longitudinal or machine direction of the tape arranged
circumferentially in the winding. In spite of the high co-
efficient of thermal expansion of the material in random
orientation, calendered material has a high coefficient of
thermal shrinkage in length, i.e., in the machine direc-
tion, and when such a wound tube is heated for sintering
the wound layers are shrunk together to produce a very
dense wall of accurate dimensions and relatively great
strength. And while others have found it necessary to
confine the wound layers of a tube to prevent expansion, as
by layers of fiber glass fabric (see Patent 2,785,173 Walk-
er), it is possible by the present invention to secure the
desired accurate dense tubing merely by the self-con-
stricting action of the wound material itself without any
mechanical confinement whatever.

The invention will be better understood from the follow-
ing description of an exemplary embodiment thereof, re-
ference being made to the accompanying drawings, where-
in:

Fig. 1 is a perspective view showing a calendered tape
being wound on a mandrel;

Fig. 2 is a perspective view showing the end seam of
the roll being sealed and smoothed down;

Fig. 3 shows several rolls on a long mandrel ready for
sintering;

Fig. 4 shows roll on mandrels moving through a sinter-
ing oven;

Fig. 5 shows a sintered roll being cut into lengths; and

Fig. 6 shows terminal sleeves being applied.

As shown in the drawings, a length of extruded and
calendered polytetrafluoroethylene sheet or tape 10 is
heated to make its layers sufficiently adherent to stick
together, as by a heater 11, and is wound on a mandrel
12 by known winding apparatus 13 to form a convolute
wound tube 14 on the mandrel. The winding apparatus
can be of various known forms, that shown being one of
the general type of that shown in Frederick 1,921,516.

There is no need to show or describe this apparatus
in detail, it being sufficient to note that a mandrel 12
is pushed into the bend of a moving belt 15 and a re-
taining roll 16 with the belt passing around it brought
down behind the mandrel. The belt runs over a heated
table 17 and can be tightened or loosened as article change
may require. The calendered tape is fed in between the
belt and mandrel and is wound on the mandrel by the
passage of the belt. The sheet fed can either be taken
from a roll and cut off when a given length has been
wound on the mandrel or can first be cut to length and
then wound on the mandrel. The latter is illustrated for
simplicity.

Each mandrel is preliminarily coated with a parting
agent of known type to assist in the later removal of the
wound tube from the mandrel.

In Fig. 1 the sheet of unsintered calendered polytetra-
fluoroethylene being fed in is shown as being advanced lon-
gitudinally in the direction in which it was run between
the calendering rolls and it has greatest strength in the
longitudinal or machine direction. The sheet also has
very considerable transverse strength to avoid splitting in
the unsintered state due to the particular method of
formation by extruding and calendering, as set forth in
the copending application of Arthur H. Haroldson et al.,
Serial No. 674,463, filed July 26, 1957, now Patent Num-
ber 2,913,786. In the extruded but uncalendered and un-
sintered state the tape has substantially no strength in the
transverse direction and will pull apart into stringy strips.

After the tube has been wound, the end of the winding
is preferably heated and pressed as by a heated iron 20
to smooth the joint and assure that there will be no
opening up at this seam in further operations.

Subsequent to winding, the tubes are sintered. This
can be done with the tubes still on the same mandrels
12 on which they were wound, but since the tubes actually
tend to shrink during sintering to grip the mandrels it is
preferable to strip them off the winding mandrels 12
and place them on a somewhat smaller mandrel to make
stripping easier after sintering. A long mandrel 21 may
be used to hold a number of lengths of tube 14 for sinter-
ing.

The tubes are sintered for the required time at the
required temperature. For example a number of man-
drels 21 with tubes thereon are shown as passing through a
sintering oven 22. The winding with the end seam
sealed has enough strength to maintain the tube size dur-
ing sintering without external confinement which has hereto-
fore been required for extruded tubes which do not have
circumferential strength and fiber orientation to pro-
vide such circumferential strength as is hereby provided
by winding calendered tape in the manner disclosed.

If the tubes tend to adhere to the mandrels after sin-
tering, in spite of pre-coating the mandrels with a release
agent, they may be loosened enough to cause them to
strip off easily by rubbing on a flat table.

The sintered tube is cut into required lengths, as shown
in Fig. 5 and a length 14c is crimped on a terminal 25,
as shown in Fig. 6.

The ability of the sleeve to be crimped and reformed
under pressure and heat, without splitting as is the case,
indicates that the sleeve has the high degree of toughness
3. The method as set forth in claim 1, further characterized by the fact that the outer end of the wound tube coil is heated and pressed to smooth the outer surface and cause the end to adhere to the coil.

4. The method as set forth in claim 1, further characterized by the fact that said sheet is heated sufficiently as it is wound on the core to make its layers hold together during further handling, and that the outer end of the wound tube coil is heated and pressed to smooth the outer surface and cause the end to adhere to the coil.

5. The method as set forth in claim 1, further characterized by the fact that the wound tube is sintered free of pressure confinement.

6. As an article of manufacture, a tube adapted to be crimped by flattening its sides without splitting or cracking, comprising a plurality of layers of extruded calendared polytetrafluoroethylene tape wound circumferentially in the machine direction as formed by the calender rolls with the layers sintered together in the wound tube.

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